International Journal of Mechanical Engineering (IJME)
ISSN(P): 2319-2240; ISSN(E): 2319-2259
Vol. 3, Issue 1, Jan 2014, 67-72

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

MECHANICAL PROPERTY ENHANCEMENT OF NATURAL RUBBER THROUGH SCF REINFORCEMENT

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ABSTRACT

Polymer Matrix Composites are usually reinforced with fibres or granules of Nylon 66, Kevlar 49, glass, carbon etc to impart better properties. The ecological concern has resulted in a renewed interest in natural polymeric materials. Natural fibre-reinforced polymer composites have gained attention among materials scientists and engineers in recent to develop an eco friendly material and partly replace currently used synthetic fibres in fibre-reinforced composites. Sansevieria cylindrica fibre is a newly invented fibre, which was analyzed very recently and is found to exhibit excellent properties. Also, the current research has established the fact that SCFs have not been utilized as reinforcement in composite materials until today, except in polyester composite. So it is decided to fabricate a new composite with this cylindrica fibre reinforcement and the matrix is selected as natural rubber since it is one of the polymer having largest domain of applications. So a whole new composite-named SCFR is fabricated by reinforcing natural rubber with cylindrical fibre and the various mechanical properties are analyzed.

KEYWORDS: Cylindrica, Decorticattion

INTRODUCTION

Polymer matrix composite materials are an emerging class of materials. They play a key role in so many applications like aerospace industry, automobile industry, construction and in other engineering applications. PMCs are usually reinforced with fibres or granules of Nylon 66, Kevlar 49, glass, carbon etc to impart better properties.

The ecological concern has resulted in a renewed interest in natural polymeric materials. Natural fibre-reinforced polymer composites have gained attention among materials scientists and engineers in recent years due to the need to develop an eco friendly material and partly replace currently used synthetic fibres in fibre-reinforced composites.

The fibres so far investigated and employed in the polymer matrix includes sisal, isora, henequen, jute, hemp etc and are proved to be a better replacement of artificial fibres.. Sreenivasan et al. [1] analysed the microstructural physico-chemical and mechanical properties of SCFs and are found to exhibit excellent properties. The current research has established the fact that SCFs have not been utilised as reinforcement in composite materials until today, except in polyester composite.

So it is decided to fabricate a new PMC with SCF reinforcement. Here Natural Rubber is choosen as the matrix material because it is one of the most widely used polymer and it's the one which finds the most number of applications.

EXPERIMENTAL PROCEDURE

Fibre Preperation

Cylindrical fibre was extracted and decorticated from the leaves of Sansevieria cylindrical plant. The fibres are uniformly cut into sets of batches of lengths 3mm, 6 mm and 10 mm. The raw sisal fibres were chopped to different lengths viz., 2, 6 and 10 mm and washed with water to remove the undesirable materials. Then these fibres were dried in an air oven at 70°C for 5 h.

Preperation of Composite and Test Specimen

The fibre was mixed with rubber on a laboratory two roll mixing mill with size 150 X 300 mm as per ASTM at a friction ratio of 1:1.25. The mill opening was set at 0.2mm. The nip gap, mill roll speed ratio and number of passes were kept the same in all mixes. The compounding ingredients were added in the exact order. The fibres were incorporated at the end of the mixing process. The samples were milled for sufficient time to disperse the fibres in the matrix at a mill opening of 1.25 mm. the stock was sheeted out after complete mixing. The homogenization was done by passing the rolled sheet six times endwise through the tight nip gap of O.8mm and finally sheeted out at a nip gap of 3mm.

Figure 1: Mixed and Specimen

This sheet was used for the processability studies. A three component bonding system consisting of resorcinol formaldehyde resin, hydrated silica and hexa are used as the bonding agent. It was added to the mix along with other ingredients during milling process as per the same mixing sequence.

The test specimens for determining the physical properties were prepared in standard moulds by compression moulding on an electrically heated hydraulic press.

Characterisation of the Specimen

Stress-strain measurements were carried out at a cross head speed 500mm/min on a Schimadzu Model AG1 universal testing machine. Tensile modulus, tensile strength and elongation at break were measured according to ASTM D 412 87 (method A). The hardness of the composite was measured using the Shore A type Durometer according to ASTM 224-81. The instrument uses a calibrated spring to provide the indenting force. The load imposed by the spring varies with indentation. Readings were taken after 15 seconds of the indentation when firm contact has been established with the specimens.

RESULTS AND DISCUSSIONS

Specimens with 3 mm, 6 mm and 10 mm raw fibres at 10 gm, 20 gm, 30 gm and 40 gm are made and analyzed in the primary stage. From these 12 composites, the one which gives the optimum result is determined.

Tensile Test

Tests were carried out according to ASTM designation using dumbbell specimens. All the above tests were

carried out at 26 ^{0}C. The sample was held tight by the two grips in a Zwick Universal testing Machine. The load at break was read from the dial. The elongation at break was measured with the help of a scale. From the recorded loads, the stress was calculated on the basis of original cross-sectional area.

By analyzing the table and the graph, maximum tensile strength is exhibited by the composite having 6 mm fibre at 20 gm concentration. Maximum modulus is also shown by the same composite, but % elongation at break is maximum for the composite with 6mm-20 gm fibre. The mechanical properties decreses as the concentration exceeds a particular level. As the fibre concentration increases, the elastomeric content decreases and their characters ceases. This is the reason for poor properties at higher concentrations.

Table 1: Tensile Test Result

Specimen	Tensile Strength (MPa)	% Elongation	Modulus
3 10	8.209	614.943	1.754
3 20	8.761	542.163	2.108
3 30	8.011	534.322	1.961
3 40	4.130	522.173	1.764
6 10	9.650	625.949	1.952
6 20	10.181	593.835	2.343
6 30	5.992	552.929	2.050
6 40	5.164	526.136	1.986
10 10	7.691	580.362	1.554
10 20	7.482	542.162	1.711
10 30	5.102	543.958	1.640
10 40	4.061	473.575	1.607

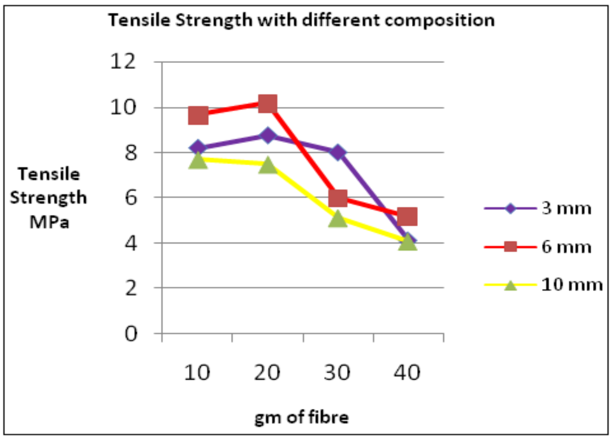

Figure 2: Tensile Strength vs Fibre Concentration

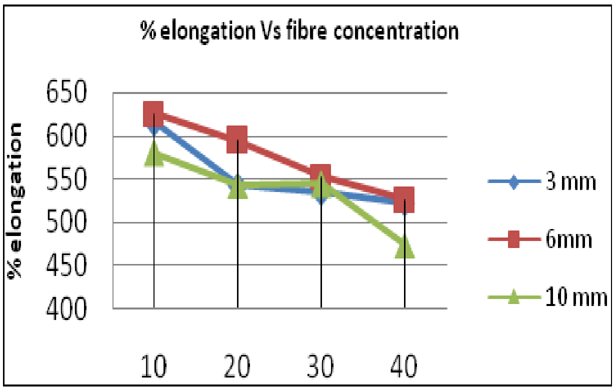

Figure 3: % Elongation vs Fibre Concentration

Tear Test

This property was tested as per ASTM D 624-81 test method, using un nicked 90° angle test specimens which were punched out from the moulded sheets, along the mill grain direction. This test was also carried out in the Zwick UTM, at a cross head speed of 500 mm per minute and at 28^{0}C. The tear strength values are reported in kN/m.

Hardness Test

The hardness of the samples was measured using a Shore A type Durometer, which employed a calibrated spring to provide the indenting force. Since the hardness reading decreased with time after tirm contact between the indentor and the sample, the reading was taken immediately after the establishment of firm contact.

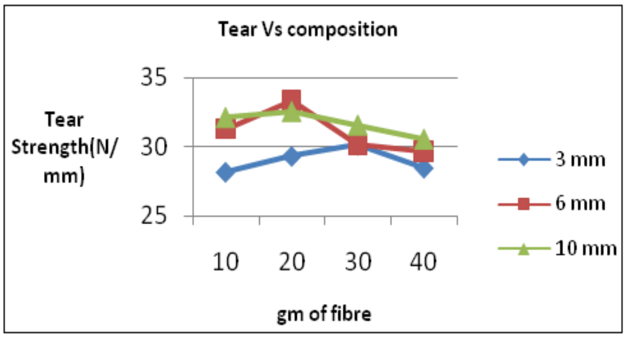

Figure 4: Tear Strength vs Fibre Concentration

Table 2: Tear and Hardness Test Result

Specimen	Tear	Hardness
3 10	28.156	52.333
3 20	29.326	69.667
3 30	30.136	71.333
3 40	28.461	74.436
6 10	31.288	50.000
6 20	33.362	68.666
6 30	30.102	71.000
6 40	29.643	74.666
10 10	32.133	49.000
10 20	32.562	69.666
10 30	31.582	69.666
10 40	30.578	73.667

By analyzing the table and the graph, maximum tensile strength is exhibited by the composite having 6 mm fibre at 20 gm concentration. Maximum modulus is also shown by the same composite, but % elongation at break is maximum for the composite with 6mm-20 gm fibre. The mechanical properties decreses as the concentration exceeds a particular level. As the fibre concentration increases, the elastomeric content decreases and their characters ceases. This is the reason for poor properties at higher concentrations.

Table and the graph shows that maximum tear resistance is shown by the composite with 6 mm- 20 gm fibre.

Hardness is maximum for the composite with 3 mm -40 gm fibre and 6 mm – 40 gm fibre. This is because as the concentration of fibre increases, the elastomeric property ceases and naturally the hardness increases.

RESULT OF REINFORCED AND GUM RUBBER

Mechanical properties of reinforced composite and without reinforcement is compared and the values are shown in the table 3.

Table 3: Result of Reinforced and Gum Rubber

Properties/Composite	SCFR	Gum Rubber
TENSILE(Mpa)	10.181	7.663
ELONGATION (%)	593.835	580.638
MODULUS (Mpa)	2.343	1.670
TEAR (N/mm)	33.362	27.351
HARDNESS (Shore A)	68.666	50.137

It is clearly evident from the table that the incorporation of cylindrical fibre has a significant effect on the enhancement of mechanical properties. Therefore it is a promising reinforcing material for the rubber matrix.

CONCLUSIONS

Composite with 6mm fibre-20 gm fibre shows max mechanical properties. A considerable enhancement of properties is imparted by the cylindrica fibre. Natural fibres in its raw state has several drawbacks. The treatment of fibres could impart a much improvement in properties. This assures that an effective treatment and a high precision manufacturing can impart a much improvement in the mechanical properties. Properties of the newly fabricated composite is compared with that of gum rubber. The fibre proves its reinforcing ability and can successfully replace the fibres that are adopted so far. So this will be a promising material. And also this will be a cost effective economy class material with superior properties.

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